ARM
Atmospheric Radiation Measurement

Fact Sheet

U.S. Department of Energy

The Atmospheric Radiation Measurement Unmanned Aerospace Vehicle Program

The Proteus in flight.

The U.S. Department of Energy's (DOE's) Atmospheric Radiation Measurement Unmanned Aerospace Vehicle (ARM-UAV) Program uses unmanned aerospace vehicles (UAVs) and occupied aircraft to make key climate measurements that cannot be made by other means.

UAVs are remotely controlled aircraft, which were originally developed for defense surveillance and are now being used in a variety of applications. Because they are unmanned, they can fly higher and longer than manned aircraft. Their long endurance at high altitudes is important in studying how clouds interact with the earth's solar and thermal radiation to heat or cool the earth.

ARM-UAV is developing UAV-compatible sensor payloads and measurement techniques and using those payloads and capabilities in UAV and piloted aircraft science flights to acquire important climate-related data.

An appropriately instrumented UAV can directly measure the atmosphere's rate of heat absorption by flying at different altitudes. At high altitudes, the UAV payload can provide calibration for satellite-based measurements. When combined with ground-based measurements, these UAV-based measurements reduce the uncertainty of predictions about "greenhouse warming," a key element in global climate research.

Capabilities

ARM-UAV is a multi-laboratory program. Sandia National Laboratories (SNL) is responsible for overall technical direction of the program. Over the life of the program, other key team members have contributed the following capabilities:

- NASA Ames, UCSD Scripps Institute of Oceanography, and Colorado State University provided radiometric instruments.
- NASA Goddard provided a microwave radiometer.
- NASA Langley conducted satellite data comparisons.
- Los Alamos National Laboratory (LANL) provided a scientific instrument calibration capability.
- Brookhaven National Laboratory (BNL) provided meteorological instruments.
- Pacific Northwest National Laboratory (PNNL) provided data management.
- University of Maryland and Florida State University provided the mission scientist for UAV missions.
- Sandia National Laboratories, Lawrence Livermore National Laboratory (LLNL), and LANL are developing highly accurate climate instrumentation, designed for UAVs.

Instruments

The ARM-UAV team has developed compact, highly accurate instrumentation for the ARM-UAV Program. These instruments include:

- A wide field-of-view, imaging cloud radiometer for retrieving cloud reflectivity, for resolving the phase of cloud droplets (ice or water) and their effective size, and for calibrating various satellite measurements (SNL).
- A fully eye-safe lidar for detecting and profiling thin cirrus clouds, which are difficult to measure by other techniques, but which may contribute significantly to the earth's radiation balance (LLNL).
- Net flux radiometer for accurately measuring the difference between the up- and down-welling radiation (LANL).

Additional instrumentation will be developed as needs are identified.

Accomplishments

The ARM-UAV Program is being accomplished in three phases:

- The first phase, to establish the utility of UAVs as an atmospheric measurement platform, has been completed. An existing UAV (the General Atomics Gnat 750) and modified versions of radiometers, which were originally developed for manned aircraft, were used in eight highly successful flights at the DOE ARM field measurement site in Oklahoma. The instrumentation measured atmospheric heating under a variety of clear-sky atmospheric conditions up to an altitude of 7 km. Preliminary analyses show excellent agreement between the resulting measurements and computational models.
- The second, interim measurement phase demonstrated important system growth capabilities through sustained operations (endurance/high altitude). This phase used existing and near-term instruments on the General Atomis "Altus" UAV, which flies at altitudes up to 20 km for more than 2 hours. Payloads for these flights consisted of instruments tailored for UAV application, to study radiation-cloud interactions, especially the recently identified enhanced cloud absorption. The highlights of this phase include an unprecedented 26+ hour science flight and an altitude record of 57,000 feet, both accomplished by the "Altus" UAV.
- The third phase, demonstrates a transition to more routine operations, which will provide airborne measurement capabilities for long periods of time in remote locations. The payload system that has been developed includes in situ as well as remote sensing instruments. This payload has been flown over the Oklahoma field measurement site and will be demonstrated at the North Slope of Alaska and in the Tropical Western Pacific at Darwin, Australia. The ultimate goal in the tropics is to use the payload system to study water vapor and radiation-cloud interactions in the upper troposphere above the Pacific warm pool, the region many call "nature's greenhouse laboratory."

For more information contact:

http://armuav.ca.sandia.gov/
ARM-UAV Program

http://www.arm.gov
ARM Program Office (509) 375-2745

ARM Program Office
P.O. Box 999, K9-38
Richland, Washington 99352

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